NOVA/BEAMLET/NIF UPDATES APRIL–JUNE 1996

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Nova Operations

During this quarter, Nova Operations fired a total of 274 system shots resulting in 288 experiments. These experiments were distributed among ICF experiments, Defense Sciences experiments, X-Ray Laser experiments, Laser Sciences, and facility maintenance shots.

As a result of gradual budget reductions over the past several years, the number of Nova Operations staff has been slowly reduced to the point that a standard double-shift operation is no longer able to be supported. In an attempt to improve facility performance, the Nova Operations group formed a team to evaluate the use of an alternate work schedule for system operations. The previous schedule consisted of two standard eight-hour shifts overlapping by one hour, five days per week. The team reviewed a variety of work schedules to determine which schedule would best meet criteria provided by the Program. As a result of their study, the team recommended four ten-hour days per week of two shifts overlapping by three hours. This alternate schedule provides slightly more time for experiments, while leaving adequate maintenance time and without requiring the use of regularly scheduled overtime. As of June 10, the operations personnel have been working this new shift. Preliminary evaluation of this work schedule indicates that the system shot rate is very near that of the standard two-shift operation and that system maintenance has improved.

A final design review was presented by Los Alamos National Laboratory for phase 2 of the Full Aperture Backscatter Station (FABS II). This diagnostic incorporates a reflecting telescope to produce a high-resolution image of the target plane. Subsequent to the review, LANL determined that the primary turning mirror produced a second surface reflection that resulted in unacceptable interference with the signal from the first surface. An alternate mirror will be coated with a wide-band, high-reflective coating on the first surface to eliminate this issue. The installation schedule for FABS II will be reevaluated after the coating of this mirror.

The Gated X-Ray Imager #5 (GXI 5), modified last quarter to use a charge-coupled-device (CCD) camera readout, is still undergoing development. During initial activation, several problems were noted and repaired. We are continuing to use this camera as opportunities arise to complete testing and work out any additional issues. The use of a CCD camera allows immediate viewing of data following a system shot.

In ongoing support of the Petawatt Project, we completed the following:

- Installation and activation of the compressor vacuum system.
- Installation and alignment of a subaperture beam-diagnostic station to support the May shot series.
- Demonstration of subaperture pulse compression in a vacuum by achieving 1.25 PW during the May shots.
- Continued system installation and activation in preparation for the full-aperture Petawatt demonstration.

We are developing a plan to install a minichamber between the Petawatt compressor and the ten-beam target chamber. This minichamber will be used during the initial Petawatt demonstration to measure system performance and beam spot at focus. The detailed engineering continues for the parabolic mirror mount, target alignment viewer, and miscellaneous diagnostic hardware required to support target experiments with the Petawatt system.

We are removing the one-beam chamber located in the west end of the two-beam area to provide a lab area for the testing of the NIF final optics assembly. Other assembly processes and hardware stored in this area are also being relocated.

Beamlet

Beamlet continues to provide the testbed to validate the laser physics foundations of the National Ignition Facility (NIF) and to check laser engineering concepts and components proposed for the NIF. During the quarter, activities on Beamlet included the following:

- We quantified the limits on power output of the NIF 1.06-μm laser design that are safe from beam filamentation in the system's 1ω optics.
- We obtained far-field images in the new dark-field-imaging diagnostic that quantified the fraction of the 1ω power scattered at small angle as a function of laser output power.
- We installed reworked 37-cm aperture frequency-conversion crystals.
- We upgraded the 3ω focal-plane diagnostic system.
- We began a series of shots to characterize the 3ω focal spot and assess the damage threat to the final optics components.
- We activated an improved control system for the deformable mirror that will allow correction for gas turbulence.

The shots to study beam filamentation propagated 200-ps-duration pulses through the unpumped booster amplifier to simulate the conditions at the end of long, high-energy, saturating pulses. The short pulses provided a "snapshot" of the most stressful part of the saturating pulse and greatly reduced the irradiance averaging that takes place when a near-field image of the entire pulse is taken. The most important diagnostic in this series was a high-magnification near-field camera recorded by a 1024 × 1024-pixel CCD camera. The results confirmed that the NIF can operate safe from filamentation with delta-B values of up to 1.8 and can have adequate margin for beam-to-beam and shot-to-shot fluctuations in output. Smaller pinholes (130 μrad in the cavity spatial filter and 100 μrad in the transport filter) provide added margin over the standard 200-μrad pinholes and are preferable.

Dark-field image data of the 1ω output were also gathered from 200-ps pulses and an unpumped booster amplifier. Much of the data came from the same shots as the 1ω near-field modulation data. The diagnostic system measured the fraction of the power scattered outside far-field beam blocks of ±33, ±66, and ±100 μrad. The data provides a measurement of (1) power scattered from imperfections and finishing errors on the optics at low laser output power and (2) the growth in this scattered power with increasing laser power. This information is useful in determining noise source values for use in laser propagation modeling.

Beginning in mid-May, we installed refinished 37-cm-aperture frequency-conversion crystals on Beamlet following their characterization on the high-resolution phase matching interferometer. At this time we also aligned and calibrated the Phase II diagnostics for the 3ω focal-plane diagnostics system. New diagnostics include a very-high-resolution near-field camera that records on photographic film, a medium-resolution near-field camera that records on a CCD array, a wide-field-of-view calorimeter, a 3ω streak camera, a multiple-plane 3ω far-field camera, and a number of new and upgraded energy sensors.

Experiments to investigate 3ω beam quality and focusability began in early June following the calibration of the new diagnostics and the angle tuning of the conversion crystals. We fired a total of 19 shots in this campaign; 14 to measure the 3ω beam quality and focal spot and 5 to characterize the focal spot obtained with a kinoform phase plate (KPP). Ten of the 14 shots without the KPP were with 200-ps-duration pulses and with the booster amplifiers unpumped to achieve delta-Bs of up to 1.8 rad at power levels up to 2 TW. We investigated both small pinholes (130-μrad cavity/100-μrad booster) and large pinholes (200-μrad/200-μrad). The focal spot data at 2.8 TW power with and without a KPP yielded 80% power half angles of 33 μrad and 20 μrad respectively and 95% power half angles of 53 μrad and 32 μrad. Preliminary analysis indicates that the spot size is strongly influenced by thermal effects in the amplifiers, as well as by output power.

At the end of June, we completed the activation of the T_0-1 second wavefront correction system. This system allows the deformable mirror to run in closed loop up to one second before shot time and thus provides the capability for wavefront correction up to the last second before shot time. On a limited number of shots during its activation, the system corrected wavefront error caused by turbulence on shots taken early in the day but was increasingly unable to make the correction as the heat accumulation in the amplifiers and the corresponding turbulence increased after repeated shots, indicating that turbulence cell sizes become smaller than the deformable mirror could correct due to its finite actuator separation.

National Ignition Facility

We made significant progress in Title I design this quarter; based on current accomplishments, the Project is expected to meet all FY 1996 critical-path milestones and complete the design as planned in September (Laser and Target Area Building conventional facility) and October (special equipment and Optical Assembly Building). The Mid-Title I Design Review, completed at the end of May, served as an interim checkpoint in the design process. The status of the mid-Title I design was presented to a review committee consisting of individuals from all the participating Laboratories as well as outside reviewers. The recommendations and comments were documented and assembled into a package and distributed to Project personnel for use in updating the design.

While the three-month total estimated cost (TEC) funding delay slowed NIF staffing and delayed the start of design, a catch-up plan was developed and implemented and is working well. This catch-up is based on a well integrated NIF/ICF team, augmented by effective use of Master Task Agreements (MTAs) with commercial companies, coupled with rapid narrowing of design options.

Engineering documentation and infrastructure are developed to the degree necessary for the current design effort. The Computer Aided Design and Drafting (CADD) systems are fully operational, the Product Data Management (Sherpa) hardware and software are implemented, and the required subsystem design requirements and interface control documents are in place.

In addition and in parallel with the intensive design effort, Title I cost and schedule estimates are being developed in all areas. The system and database are operational, with inputs generated by the responsible engineers and the system and rates controlled by the NIF Project Office. Initial inputs are essentially complete, and verification is under way.

Specific progress in the various areas is outlined below.

- The contract for construction management services was awarded to Sverdrup, and personnel were onboard for the Mid-Title I Design Review. Fast tracking is being considered to meet the construction schedule milestones, and special construction methods are being evaluated.
- The NIF general arrangement drawings for the NIF Laser and Target Area Building (LTAB) have been completed and are under configuration control. Design iterations continue for cost containment and reduction to assure that the design results in the minimum platform to achieve the requirements.
- An embedded laser-amplifier structure that offers important installation and operational advantages over the original conceptual design was developed and is the basis of the Title I design. This approach also simplifies utility interfaces above the amplifiers, which are now an integral part of the structure.
- Following an extensive technical and cost tradeoff evaluation, we selected flexible transmission lines for power conditioning over rigid lines and established a routing layout. Flexible lines result in easier installation and improved accessibility.
- We optimized the preamplifier module/preamplifier beam transport system layout to permit the output sensor packages to be located underneath the transport spatial filter for reduced cost and improved stability and operational accessibility. We completed the preamplifier module maintenance area layout and utility requirements.
- We have successfully resolved numerous conflicting requirements in the beam transport system and have established an end-to-end comprehensive design solution (see Fig. 1). Space allocations have been frozen for all laser bay and switchyard subsystems. Baseline switchyard and laser bay structures, which meet all stability, access and safety requirements, have been established and integrated with the other systems.
- We selected a hybrid concrete-steel construction early in the quarter for use on all the laser bay support structures. Detailed analysis confirmed the performance advantage of the hybrid structure over all-steel or all-concrete structures. The laser support structures have been integrated with all other subsystems.

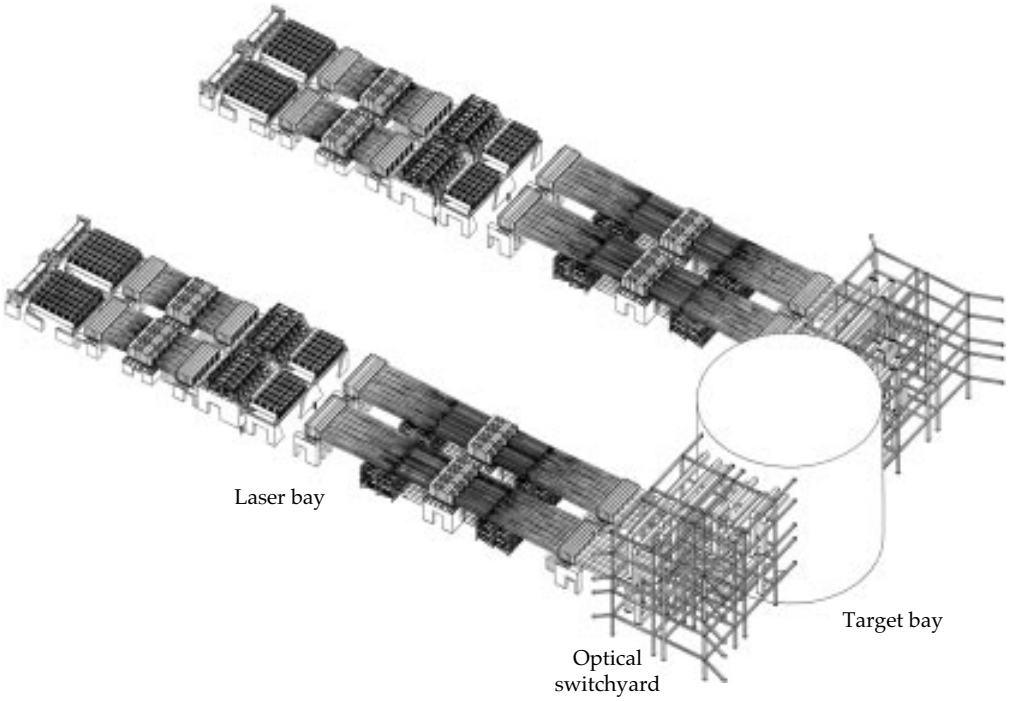


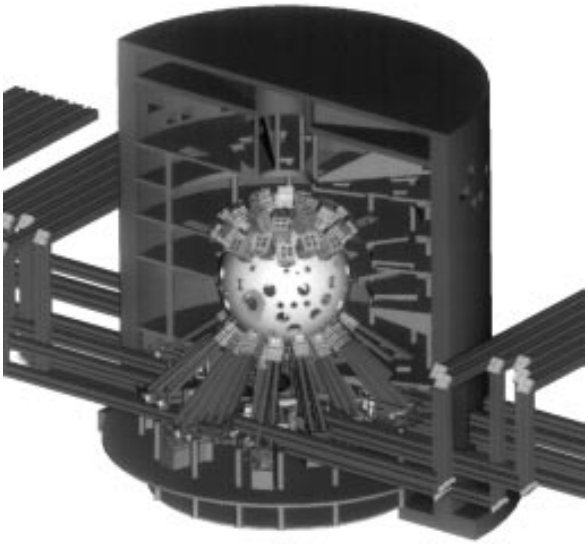
FIGURE 1. A comprehensive "end-to-end" integrated design has been developed. (40-00-0796-1771pb01)

- In collaboration with the ICF Core Science and Technology Program, a NIF prototype automatic-alignment loop, based on analysis of the beam profile and commercial Datacube processing system, was activated and is undergoing tests. CORBA and Ada95 software, which are planned for NIF use, are currently being tested in the front-end processors.
- We established the optical component layout for the main laser system. Title I optics sizes and thickness have been established, component spacing issues resolved, and configuration drawings generated for the laser optical train. We have completed individual system elements of the clear-aperture budget analysis, and integration and consistency checks are in progress.
- We resolved complicated design issues in the transport spatial filter, including optics locations, and paths for injection, alignment, diagnostics, wavefront control, and main beams. The optical stability has been improved by use of top-loading towers separate from the vacuum chamber.
- Major revisions to the target area design were carried out to incorporate the color separation filter in the final optics assembly. The beam transport codes were revised, the building configuration modified, new analytic models of the building developed, and the mirror supports redesigned and presented at the Mid-Title I Design Review.
- The finite-element integrated target-building/switchyard-structures model was refined to reflect the most recent design details (see Fig. 2). We continue to analyze structural/damping supports between the chamber/pedestal and target building floors. We delivered structural drawings of the target room floors, ribs, columns, and associated equipment loads to the LTAB Architecture/Engineering firm, Parsons, for their civil and structural analysis. Layouts of the target room floors and special equipment lasers were also delivered so that Parsons could model the area for the thermal analysis.
- Material flow studies have been effective in resolving LTAB corridor, doorway, and elevator size requirements. Development continued on requirements for optics transport and handling, and requirements for top-loading line replacable units were evaluated.
- The *Final Programmatic Environmental Impact Statement* is complete except for DOE comment resolution. The *Preliminary Safety Analysis Report* was completed as scheduled and submitted to DOE for concurrence review.

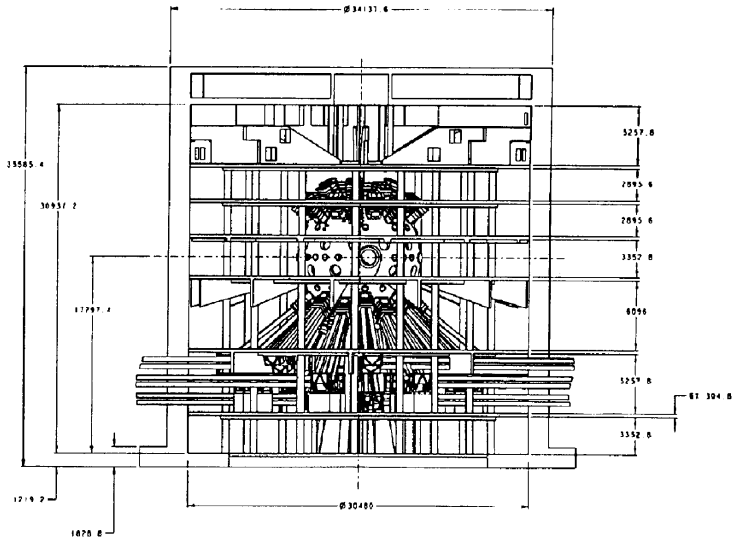
Twelve students from colleges and universities throughout the country, representing a number of technical disciplines, are employed by the NIF Project for the summer supporting the above activities.

Planning for the Title I Design Review is well under way. The Title I Design Review Plan was completed and released to Project personnel for their use in detailed planning of the remaining Title I work. The plan includes the overall objectives, organization, and schedules, as well as the agenda for the review meetings and contents of the Design Basis Books. The overall chairman of the review committee was selected and considerable progress made in identifying review committee members that will include DOE and external reviewers.

During the coming quarter, Title I documentation packages including design, cost, and schedule will be prepared, and the Title I Design Reviews will begin.



3-D CADD model



NIF drawing no. NM96-1.8.1-0000044-A

FIGURE 2. Engineering drawings are rapidly emerging from a comprehensive 3-D solid CADD model. (40-00-0796-1633pb01)